NASA SBIR 2020 Phase I Solicitation

A1.04 Electrified Aircraft Propulsion

Lead Center: GRC

Participating Center(s): AFRC, LaRC

Technology Area: TA15 Aeronautics

Scope Description

Proposals are sought for the development of energy storage, propulsion airframe integration, power distribution, thermal, tools/modeling approaches, electric machines and electrical power conversion that will be required for aircraft which use turbo-electric, hybrid electric or all electric power generation as part of the propulsion system. A related STTR topic (T15.03) for electric aircraft propulsion energy storage is offered in parallel. Turbo-electric, hybrid electric, and all electric power generation, as well as distributed propulsive power, have been identified as candidate transformative aircraft configurations with reduced fuel consumption/energy use and emissions. However, components and management methods for power generation, distribution, and conversion are not currently available in the high power ranges with the necessary efficiency, power density, electrical stability and safety required for thin haul/short haul, or transport-class aircraft. Novel developments are sought in:

- Energy storage systems with specific energy >400 Whr/kg at the system level and cycle life >10,000 cycles. This subtopic seeks energy solutions in the Technology Readiness Level (TRL) 3-5 range, appropriate for near-term applications. Proposers working on lower TRL energy storage technologies with a research institution partner should consider proposing to the "Electrified Aircraft Propulsion Energy Storage" subtopic in the STTR solicitation.
- Additive manufacturing solutions for the seamless integration of thermal management technology within the Electrified Aircraft Propulsion (EAP) powertrain, airframe, thermal sources and sinks to minimize system mass and thermal impedance through a tight airframe integration scheme that potentially provides a multi-functional structure solution (load bearing and thermal transport).
- High voltage lightweight fault management devices with individual device rating of 600-3000 V DC, 200-1000 A.
- Design and analysis of airframe-integrated, high-performance distributed electric propulsion (DEP) inlet/fan systems and the resulting effect on: (1) distortion and swirl at the aerodynamic interface plane (AIP), (2) fan efficiency, stability and structural robustness, and (3) operation of adjacent flow paths for DEP inlet/fan concepts and/or boundary layer ingestion (BLI) aircraft.
- Lightweight electrical insulation materials/composites for high altitude, high voltage power transmission with dielectric breakdown strength (V/m) of the insulation minimally 2.5 times that of the operating electric field stress (V/m) at the conductor surface, high resistivity (1019 to 106 Ω×cm), low dielectric dissipation factor (tan δ), Insulation Class H (180° C) to Class C (>240 °C), moisture resistant, good mechanical properties and improved thermal conductivity, above 0.5 W/m*K.
- Additive manufacturing processes and advanced materials for future generation electric motor designs and windings which provide lower costs, compact designs (>25% volume reduction), lighter weight (>30%
reduction), advanced cooling/improved thermal conductivity, multi-materials and/or greatly improved material or component properties which significantly contribute toward improved electric machine performance. Maintaining electrical insulating and lifetime properties over repetitive thermal cycling, along with being resistant to corona effects, is of interest.

References:

Electrified Aircraft Propulsion (EAP) is called out as a key part of Thrust 4 in the Aeronautics Research Mission Directorate (ARMD) strategic plan: https://www.nasa.gov/aeroresearch/strategy

Overview of NASA's EAP Research for Large Subsonic Aircraft: https://ntrs.nasa.gov/search.jsp?R=20170006235


Expected TRL or TRL range at completion of the project: 2 to 6

Desired Deliverables of Phase II

Prototype, Analysis, Hardware, Software, Research

Desired Deliverables Description

Deliverables vary considerably within the topic, but ideally proposals would identify a technology pull area (with a market size estimate), how the proposed idea addresses the needs of the technology pull area and then deliver a combination of analysis and prototypes that substantiate the idea's merit.

State of the Art and Critical Gaps:

The critical technical need is for lightweight, high-efficiency power distribution systems and energy storage that have flight-critical reliability. Typically, the weight needs to be reduced by a factor of 2-3 and efficiency needs to be improved. Higher efficiency reduces losses and makes thermal management more achievable in an aircraft. Another need for medium to large aircraft is the ability to operate at voltages above 600V. This capability results in reduced weight, however, is called out specifically because it impacts all of the power system components.

Technologies that address these gaps enable Electrified Aircraft Propulsion which enables new aircraft configurations and capabilities for the point-to-point on-demand mobility market and a new type of innovation for transport aircraft to reduce fuel consumption and emissions.

Relevance / Science Traceability:

Electrified Aircraft Propulsion (EAP) is an area of strong and growing interest in ARMD. There are emerging vehicle level efforts in Urban On-Demand Mobility, the X-57 electric airplane being built to demonstrate EAP advances applicable to thin and short haul aircraft markets and an ongoing technology development sub-project to enable EAP for single aisle aircraft. Additionally, NASA is formulating a MW-level EAP flight demo this year.

Key Outcomes NASA intends to achieve in this area are:

- Outcome for 2015-2025: markets will begin to open for electrified small aircraft.
- Outcome for 2025-2035: certified small aircraft fleets enabled by electrified aircraft propulsion will provide new mobility options. The decade may also see initial application of electrified aircraft propulsion on large aircraft.
- Outcome for >2035: The prevalence of small-aircraft fleets with electrified propulsion will provide improved economics, performance, safety, and environmental impact, while growth in fleet operations of large aircraft with cleaner, more efficient alternative propulsion systems that will substantially contribute to carbon reduction.

Projects working in the vehicle aspects of EAP include:
- Advanced Air Vehicles Program (AAVP) / Advanced Air Transport Technology (AATT)
- Integrated Aviation Systems Program (IASP)/ Flight Demonstrations & Capabilities (FDC) Project
- Advanced Air Vehicles Program (AAVP)/Revolutionary Vertical Lift Technology (RVLT) Project

Transformative Aeronautics Concepts Program (TACP)/Convergent Aeronautics Solutions (CAS) Project